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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of:	Atty. Docket: **TM&K0008**
Shinji TAKEDA et al.	
Serial No. 09/785,486	Group Art Unit: 2814
Filed: April 5, 2000	Examiner: D. GRAYBILL
For: SEMICONDUCTOR DEVICE AND PROCESS FOR FABRICATION THEREOF	

DECLARATION UNDER 37 C.F.R. § 1.132

Assistant Commissioner for Patents
Washington, D. C. 20231

1. I, MASUKO Takashi, state that I am an expert in the field of semiconductor research and development. I received a Master of Science degree in Environmental Science from University of Tsukuba in March 1992. I worked in Tsukuba Research Laboratory, Hitachi Chemical Company Ltd. from April 1992. I have worked in Packaging Material Laboratory, Research & Development Center, Hitachi Chemical Company Ltd. since June 1999. I have been engaged in development of die attach materials since 1992.

2. I have authored or co-authored and published the following papers.

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1. S. Takeda, T. Masuko, Proceedings of the 1997 Electronic Components and Technology Conference (ECTC) pp. 518-524, 1997

2. S. Takeda, T. Masuko, Proceedings of the 2000 Electronic Components and Technology Conference (ECTC) pp. 1616-1622, 2000

3. T. Masuko, S. Takeda, Proceedings of the 9th Micro Electronic Symposium (MES), pp. 249-252, 1999

4. S. Takeda, T. Masuko, Hitachi Chemical Technical Report, No. 24, pp.25-28,1995

3. I am familiar with the above captioned patent application and understand that certain prior art references were cited against the claims of the application. Specifically, I am familiar with the Morita et al. reference (U.S. Patent 5,406,124).

4. The foregoing experimental results were collected directly by me, or by others under my direct supervision, and that the experiments were performed with my understanding and knowledge.

5. **Experimental Conditions**

The purpose of the experiment was to compare the closest prior art filmy organic die-bonding material ("prior art film") to the filmy organic die-bonding material of the present invention ("novel film"). Specifically, we utilized the film disclosed by Morita et al. (U.S. Patent 5,406,124) as the closest prior art film and compared the adhesion characteristics (peel

strength) and the durability (rate of occurrence of reflow cracks) of the prior art film to the novel film.

6. **Prior Art Film**

The prior art film was produced using the method described by Morita as "EXAMPLE 1" (column 14, line 60 to column 15, line 2). An amount of 14.6 g (0.05 mol) of 1,3-bis(3-aminophenoxy)benzene and 92.1 g of N.N-dimethylacetamide were introduced into a container equipped with an agitator, a reflux condenser, and a nitrogen pipe. Thereafter, 16.0 g (0.0495 mol) of 3,3',4,4-benzophenonetetracarboxylic acid dianhydride was divided into four portions and added into the container under nitrogen atmosphere at room temperature and the mixture was stirred for 20 hours at room temperature. This process produced a polyimide acid varnish.

Next, a Base film of 50 μm thickness was coated on both sides with the polyimide varnish produced by the previous steps. The coated film was then dried at 100°C for 1 hour followed by drying at 250°C for 1 hour. The result was a three-tiered film having a 10 μm thick polyimide layer (Tg200°C) corresponding to the prior art film of Embodiment No. 1 of the Morita reference (See Table in Morita reference).

7. **Novel Film**

The novel film was produced using the method disclosed in the specification as originally filed (page 19, line 13 to page 20, line 21). An amount of 280 g of organic solvent (N-methylpyrrolidone) was added to 100 g of polyimide, specifically identified as Polyimide F in the specification and made from DBTA (1, 10-(decamethylene)bis(trimellitate

anhydride)/BAPP(2,2-bis[4-(4-aminophenoxy)phenyl] propane), in 10 g of epoxy resin. The mixture was stirred thoroughly until the mixed solution was homogeneously dispersed. The product of these steps was a coating varnish .

Next, a carrier film (OPP film; biaxially stretched polypropylene) was coated with the coating varnish of the previous step. The coated carrier film was then heated in a dryer with internal air circulation for 30 minutes at a temperature of 80°C followed by 30 minutes at 150°C. This heating process evaporated the solvent and dried the varnish. After drying, the carrier film was removed and the resulting novel film obtained had a thickness of 20 μm. This film corresponds to film No. 8, Table 1 of the specification (page 21).

8. **Evaluation of Films**

(1) Evaluation of film adhesiveness

To evaluate film adhesiveness, the prior art and novel films were cut into 5 x 5 mm sized pieces. Each piece of film was then die-bonded to a 42 alloy lead frame at a temperature of 250°C and a pressure of 120gf/mm^2 maintained for 5 seconds. Each film was subsequently die-bonded to a 5 x 5 mm silicon chip to form the structure (21, 22, 23) illustrated in Figure 2 of the specification. The experiment was repeated under three different die-bonding conditions. Table 1 shows the conditions under which 5 x 5 mm silicon chips were die-bonded to the lead frame.

Peel strength was measured by a push-pull gauge at a test speed of 0.5 mm/minute as it was described in the present invention's specification (page 33, lines 1-16; Figure 2), except that the samples tested were the lead frame die-bonded to silicon chips via either the prior art

film or the novel film respectively. Furthermore, it is noted that each sample was tested at its respective die-bonding temperature for 20 seconds. The results are expressed as the force in kgf per chip required to peel the silicon chip from the lead frame.

Table 1

Die-bonding Condition	Reason for using the condition	Film	Peel strength (kgf/chip)
250°C x 30gf/mm^2 x 20 sec	Described in a claim (Preferable condition)	Morita's film	0.40
		Novel film	>6 (All chips destroyed)
250°C x 4gf/mm^2 x 2 sec	Described in a claim (Preferable condition)	Morita's film	0.03
		Novel film	1.15
230°C x 0.6gf/mm^2 x 1 sec	Condition of Example 2 No. 7-10 of the present invention	Morita's film	0.00 (No adhesion occurred)
		Novel film	0.55

(2) Evaluation of reflow cracks

As described in section 7, subparagraph (1) supra, we used identical die-bonding conditions when die-bonding films and chips. To evaluate the rate of occurrence of reflow cracks, semiconductor devices were fabricated utilizing either the prior art film or the novel film. The method of fabricating the semiconductor devices is that method disclosed in the specification (page 19, line 25 to page 20, line 21), with the exception that the die-bonding was carried out at the conditions specified in Tables I and II of this declaration. After the die-bonding was carried out, the product underwent wire bonding and then molding with an encapsulant material (CEL-9000, Hitachi Chemical Co., Ltd.) to form a semiconductor device.

Each semiconductor device was then treated in a thermo-hygrostat at 85°C and 85% relative humidity (RH) for 168 hours, and thereafter heated at 240°C for 10 seconds in an infrared reflow furnace.

The rate of occurrence of reflow cracks was determined by molding each semiconductor device with polyester resin, then cutting each device with a diamond cutter to expose a cross section. Each cross section was observed via a microscope for cracks (referred to as "reflow cracks," specification, page 2, lines 16-19). The rate (%) of occurrence of reflow cracks is defined by the following expression: rate (%) of occurrence of reflow cracks = (number of occurrence of reflow cracks/number of tests) x 100. The test results are presented in Table 2.

Table 2

Die-bonding Condition	Reason for using the condition	Film	Rate of occurrence of reflow cracks (%)
250°C x 30gf/mm^2 x 20 sec	Described in a claim (Preferable condition)	Morita's film	100
		Novel film	0
250°C x 4gf/mm^2 x 2 sec	Described in a claim (Preferable condition)	Morita's film	100
		Novel film	0
230°C x 0.6gf/mm^2 x 1 sec	Condition of Example 2 No. 7-10 of the present invention	Morita's film	100
		Novel film	0

9. **Discussion of the Results**

As is clearly shown in Table 1, under each set of die-bonding conditions, the novel film outperformed the adhesiveness of Morita's prior art film. Unexpectedly, the adhesiveness of

the novel film was so great when die-bonded under certain conditions that it could not be fully measured (kfg > 6) by the conventional test used in this experiment because the silicon chips would break before the adhesion of the novel film would give way.

As is clearly shown in Table 2, under each set of die-bonding conditions, the novel film outperformed Morita's prior art film in an unexpected way. Specifically, while every one of the semiconductor devices made with the prior art film demonstrated reflow cracks, none of the semiconductor devices made with the novel film suffered these defects. This result is plainly not a matter of degree, but is a matter of unexpected invulnerability.

10. I declare under penalty of perjury that the foregoing is true and correct, that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed by,

Date: March 5, 2002

Takashi Masuko
Takashi MASUKO